

QUALITY RESPONSE OF 'BING' AND 'RAINIER' SWEET CHERRIES TO LOW DOSE ELECTRON BEAM IRRADIATION

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ABSTRACT

'Bing' and 'Rainier' sweet cherries were irradiated at doses of 0.00, 0.15, 0.30, 0.60 and 0.90 kGy using a linear accelerator. Cherries were evaluated for quality immediately after treatment and again after 14 days storage at 1°C. No variation in soluble solids, titratable acidity or flavor were noted at any of the irradiation doses. Defects were increased for 'Rainier' cherries at irradiation doses above 0.60 kGy, but no change in defects of 'Bing' cherries were present regardless of irradiation doses. Objective color of 'Bing' cherries was lighter with more red at irradiation doses greater than 0.30 kGy, but this change in color was not evident visually. Objective color of 'Rainier' cherries was reduced at irradiation doses of 0.60 kGy and greater. This reduction in 'Rainier' red color was evident visually at an irradiation dose of 0.90 kGy. No change in 'Bing' green stem color was evident, but 'Rainier' stem color improved at irradiation doses above 0.60 kGy. Firmness of both 'Bing' and 'Rainier' cherries was reduced at irradiation doses of 0.60 kGy and greater. By using the linear accelerator at doses of 0.60 kGy or less, 'Bing' and 'Rainier' cherries can be irradiated with no major quality loss to meet quarantine requirements.

Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the exclusion of others that may also be suitable.

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INTRODUCTION

Export of agriculture commodities to foreign markets is of major interest to the United States. Fumigation of fruit products with methyl bromide (MeBr) to control insect pests to meet quarantine requirements has met with varying degrees of success due primarily to injury to the host fruit. At the present time, regardless of the problems associated with fumigants, MeBr is the only fumigant accepted by most countries that import fruits and vegetables. The future of MeBr as a quarantine treatment is in doubt. In the year 2001 MeBr will be banned as a fumigant in the United States (Stephens 1996). To continue to export agriculture commodities, alternatives to MeBr must be determined.

One of the alternatives to MeBr insect control is irradiation. Considerable research has been conducted on irradiation of fruits and vegetables for insect disinfestation and postharvest losses. Most of the early research was directed toward producing microbe-free food products with greater shelf-life. Levels of gamma irradiation necessary to sterilize can cause severe injury to fresh commodities. Maxie *et al.* (1971) reported major quality problems associated with fresh commodities after exposure to irradiation treatment. Eaton *et al.* (1970) reported the effect of irradiation was cultivar dependent for cherries and blueberries. Miller *et al.* (1994) concluded that blueberry quality was not influenced by electron beam irradiation at levels of <1.0 kGy. Eakin *et al.* (1985) concluded that codling moth (*Cydia pomonella* L.) control can be achieved with an irradiation dose of less than 0.25 kGy, and irradiation doses less than 0.60 kGy caused no adverse effects on 'Bing' cherry quality. Kader (1986) suggested that sweet cherries could be exposed to irradiation at levels sufficient for insect disinfestation (<1 kGy) with little or no quality loss. Jessup (1990) determined that an irradiation dose of 75 Gy prevented exclusion of Queensland fruit fly, and that the quality of 'Bing' and 'Lambert' cherries was not influenced by greater doses. Drake *et al.* (1994) reported that 'Rainier' sweet cherries were tolerant to irradiation dose levels of 1.0 kGy or less with little quality loss except for a reduction in firmness. Currently the FDA allows for the use of 1.0 kGy or less on fruits and vegetables (Kader 1986).

Previous studies with irradiation were conducted using gamma source irradiation. Recently, interest was expressed in the use of electron beam irradiation. Information concerning the quality response of fruits and vegetables to electron beam irradiation is limited. This study was conducted to determine the quality response of 'Bing' and 'Rainier' sweet cherries to electron beam irradiation.

MATERIALS AND METHODS

'Bing' and 'Rainier' sweet cherries (55 kg each) were obtained from commercial sources the day of harvest in 1994 and 1995. Cherries were divided immediately into groups of 2.5 kg and packed into lined boxes ($46 \times 25 \times 5$ cm). The boxed cherries were packed in Coleman coolers (5 boxes/cooler) containing 2.5 kg of gel refrigerant and a temperature recorder. Boxed cherries were shipped overnight express to the Florida Dept. of Agriculture and Consumer Services, Div. of Plant Industry, Irradiation Research Facility, Gainesville, FL (1994) or the Iowa State University, Irradiation Research Facility, Ames, IA (1995) for treatment. The boxed cherries were irradiated (0.00, 0.15, 0.30, 0.60 and 0.90 kGy) using the linear accelerator at each of these facilities. After treatment the cherries were returned overnight express to the USDA-ARS, Tree Fruit Research Laboratory, Wenatchee, WA. The time required for shipment and treatment did not exceed 50 h and the maximum temperature in the Coleman cooler during shipment did not exceed 10C. Quality evaluations on the cherries were determined prior to the initial shipment, immediately upon returning and after 14 days of storage at 1C.

Quality evaluation consisted of objective and subjective color, firmness, soluble solids content (SSC), carbohydrates, titratable acidity and evaluation for defects. Objective color of fruit and stems was determined with The Color Machine (Pacific Scientific, Silver Springs, MD) using the Hunter L, a, b system and calculated hue colors (Hunter and Harold 1987). Subjective color was determined using two laboratory personnel familiar with cherry color grades. Fruit and stems were rated individually on a scale of 1 to 3 (1=best; 3=poorest) and the mean value reported. Firmness was determined using the Universal TA-XT2 texture analyzer equipped with a 3-mm probe set at 10 mm/s and a penetration distance after contact of 7 mm and the values were expressed in Newton (N). SSC of the cherries were determined with an Abbe-type refractometer with a sucrose scale calibrated at 20C. Acids were titrated to pH 8.2 with 0.1N NaOH and expressed as percentage of malic acid. Carbohydrates (sucrose, glucose, fructose and sorbitol) were determined by the HPLC procedure described by Bio-Rad (Bio-Rad, Richmond, CA). Defects (pitting and bruising) were graded by two laboratory personnel as present or absent. Analysis of variance was determined by (MSTAT 1988) with irradiation dose level as the main plot and storage time as the subplot. Based on significant F-test, means were separated using Tukey's Test ($P > 0.05$). No consistent interaction between radiation dose level and storage time existed, therefore only the main effects are presented.

RESULTS AND DISCUSSION

Electron beam irradiation resulted in a loss of firmness for 'Bing' cherries (Table 1). This loss of firmness was present at the lowest dose of irradiation (0.15 kGy). Irradiation doses between 0.15 and 0.60 kGy produced no additional reduction in firmness of 'Bing' cherries. But, irradiation treatment greater than 0.60 kGy resulted in a decrease in fruit firmness of more than 25% for 'Bing' cherries when compared to nonirradiated cherries. The firmness of 'Rainier' cherries did not decrease until the irradiation dose exceeded 0.60 kGy. Between 0.60 and 0.90 kGy the firmness of 'Rainier' cherries decreased 16%. This reduction in firmness values is similar to reported losses in firmness of 'Bing' cherries when MeBr is used as a fumigant (Drake *et al.* 1991) and to the reported losses of firmness in 'Rainier' cherries when exposed to Cobalt 60, gamma radiation (Drake *et al.* 1994). SSC, titratable acidity, fruit weight and fruit defects of 'Bing' cherries were not influenced by irradiation treatment. SSC, carbohydrates and fruit weight of 'Rainier' cherries were not influenced by irradiation treatment. A loss in titratable acidity and an increase in fruit defects were present for 'Rainier' cherries at an irradiation dose greater than 0.60 kGy. Increased defects were present in 'Bing' cherries at irradiation dose levels above 0.60 kGy, but it was difficult to distinguish defects in 'Bing' cherries due to their dark red color. 'Rainier' cherries are light yellow in color and any difference in defects would be obvious. 'Rainier' cherries are delicate and require special handling to reduce injury (Drake *et al.* 1991).

Under present marketing procedures, fruit and stem color greatly influence consumer perception of cherry quality. Hunter color "L" values for 'Bing' cherries increased at irradiation doses greater than 0.15 kGy (Table 2). The change in "L" values was at least a 1 unit increase for each subsequent irradiation dose. As little as one unit of color difference is visible to the human eye (Hunter and Harold 1987). Hue values decreased (more red) for 'Bing' cherries at irradiation doses greater than 0.15 kGy. The decrease in hue values (more red) was not as distinct as the increase in "L" values (lighter color) and did not continue at irradiation doses greater than 0.30 kGy. These changes were not apparent to laboratory personnel when visual color was assessed. No change in visual color of 'Bing' cherries was observed regardless of irradiation dose. If Hunter "L" and hue values are considered, a lighter and redder 'Bing' cherry color would be expected after irradiation doses greater than 0.30 kGy. No change in Hunter "L", hue or visual color was observed for 'Bing' cherry stems regardless of irradiation dose.

Hunter "L" values (lightness and darkness) for 'Rainier' cherries at irradiation doses of 0.00 kGy and 0.90 kGy were similar. At irradiation doses less than 0.90 kGy, there was some change in Hunter "L" values, but no pattern of increase or decrease was established. Hue values of 'Rainier' cherries displayed a change

TABLE 1.
QUALITY ATTRIBUTES OF 'BING' AND 'RAINIER' CHERRIES USING AN ELECTRON
BEAM LOW DOSE IRRADIATION SOURCE, 1994-95

	<u>'BING'</u>					<u>'RAINIER'</u>				
	Firmness (N)	SSC (%)	TA (%Malic)	Wt (g)	Defects	Firmness (N)	SSC (%)	TA (% Malic)	Wt (g)	Defects
<u>Radiation</u>										
0 kGy's	4.9a ²	17.4a	0.55a	5.8a	2.3a ²	4.4ab	19.3b	0.52a	7.2a	2.5b
0.15	4.3b	17.4a	0.54a	5.9a	2.2a	4.5a	20.2a	0.52a	7.3a	2.3b
0.30	4.2bc	17.8a	.54a	6.0a	2.2a	4.5a	20.4a	0.51ab	7.2a	2.4b
0.60	4.2bc	17.3a	.55a	6.0a	2.2a	4.3b	19.7a	0.51ab	7.1a	2.5b
0.90	3.6c	17.6a	.52a	5.9a	2.2a	3.7c	19.5b	0.48b	7.4a	3.4a
<u>Storage</u>										
0 days	4.3a	17.6a	0.53a	5.8b	1.4b	4.2b	19.9a	0.53a	7.2a	2.5a
14	4.2a	17.4a	.55a	6.1a	3.0a	4.4a	19.7a	0.49b	7.3a	2.6a

²Means within treatments not followed by a common letter are significantly different

²Defects graded visually on a scale of 1 to 3 (1=none, 2=slight and 3=severe)

at doses greater than 0.60 kGy, indicating a lighter yellow color for cherries treated at the greater doses. Visual color was less acceptable at 0.90 kGy than at the smaller doses. Stem color improved at irradiation doses of 0.30 kGy and greater. Increased Hunter "L", decreased hue values and better visual stem color was present at doses of 0.30 kGy and greater. Changes in Hunter "L" and hue values were in excess of 1 color unit and were visible to laboratory personnel.

Storage of both 'Bing' and 'Rainier' cherries at 1C for 14 days resulted in reduced quality. There was no relationship between storage and irradiation treatment regardless of dose. Both 'Bing' and 'Rainier' cherries, are very perishable commodity regardless of treatment and can not be stored more than two to three weeks for good quality maintenance.

CONCLUSION

Considering irradiation doses necessary for quarantine (< .60 kGy) and the lack of quality loss in 'Bing' and 'Rainier' cherries at 0.60 kGy and less, these two cultivars are good candidates for quarantine treatment using the linear

TABLE 2.
FRUIT AND STEM COLOR 'BING' AND 'RAINIER' CHERRIES, USING AN ELECTRON BEAM LOW DOSE
IRRADIATION SOURCE, 1994-95

<u>'RAINIER'</u>														
<u>Fruit</u>				<u>Stem</u>				<u>Fruit</u>				<u>Stem</u>		
L	hue	Visual Color	L	hue	Visual Color	L	hue	Visual Color	L	hue	Visual Color	L	hue	Visual Color
<u>Radiation</u>														
0 kGy's	28.3d ^z	13.7a	1.9b	35.7a	105a	1.6a ^y			42.9c	36b	1.9b	30.8c	127a	1.7a
0.15	28.8d	12.8a	2.2a	35.8a	106a	1.5a			45.4ab	36b	2.1b	31.2bc	121ab	1.6ab
0.30	30.4c	11.8ab	1.9b	36.3a	107a	1.5a			44.9b	36b	2.1b	31.9ab	116b	1.7a
0.60	32.1b	10.0b	1.9b	36.6a	107a	1.5a			47.0a	39a	2.1b	32.5a	121ab	1.5bc
0.90	33.1a	10.6b	2.0b	37.0a	106a	1.5a			44.2bc	38a	2.2a	32.6a	124ab	1.4c
<u>Storage</u>														
0days	27.0b	9.2b	1.3b	35.5b	103b	1.4b			42.2b	36b	1.8b	29.7b	128a	1.4a
14	34.1a	14.4a	2.7a	37.0a	109a	1.6a			47.6a	38a	2.4a	33.9a	116b	1.7b

^zMeans within treatments not followed by a common letter are significantly different

^yVisual color assesment on a scale of 1 to 3 (1=good, 2=fair and 3=poor)

accelerator. Jessup (1990) and Drake *et al.* (1994), reported that cherries treated for insect disinfestation with Cobalt 60 gamma radiation showed little quality loss. Quality loss in irradiated sweet cherries is minimal when one considers that the more conventional means of disinfestation (MeBr) result in considerable quality loss (Drake *et al.* 1991). Disinfestation by gamma or electron beam irradiation is equal to or superior to fumigation with MeBr based on product quality assessment.

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